Newington Photovoltaic Power Systems
Energy Value and Reliability Analysis

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Contents

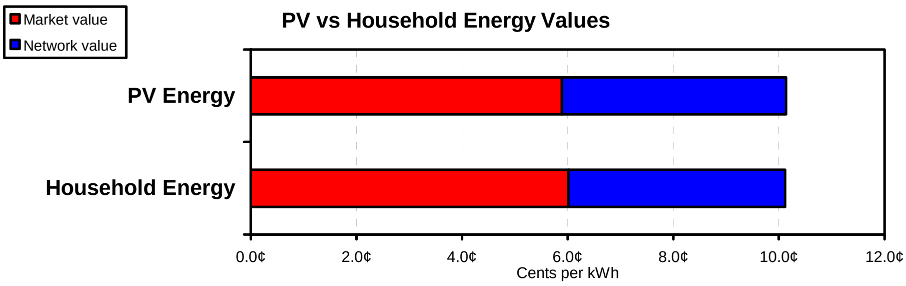
1 Executive Summary

The Sydney suburb of Newington includes over 800 dwellings with rooftop PV (photovoltaic) systems, which were once part of the Athlete's Village for the 2000 Sydney Olympics. The Demand Management and Planning Project collected energy data at half-hourly time intervals from 30 of these dwellings between 9 July 2004 and 8 July 2005. This interval data has been used to calculate the comparative value of the energy from the PV systems, both in the wholesale energy market and as an offset to network costs.

Based on the prices in the wholesale energy market at the time, the average energy value of the household consumption profile was 6.01 ¢/kWh and the value of the PV production was similar at 5.89 ¢/kWh.

The value of the network offset was also calculated using the 2007/08 residential network TOU (Time Of Use) tariffs, and showed that average cost of the household consumption profile was 4.11 ¢/kWh, which was again similar to the value calculated for the PV production of 4.25 ¢/kWh.

These results confirm that for this sample, the PV production profiles did not correspond more to higher pool price periods than typical household consumption profiles. The results for network tariffs reinforce earlier studies that suggested PV installations provided little benefit to networks, at least for Sydney based systems.



The systems studied exported an annual average of 365kWh to the grid. Calculating the value of the exported energy gave an energy value of 5.39¢/kWh and an average network value of 3.89¢/kWh. This suggests, not surprisingly, that the household consumes the higher value energy and the energy exported is less valuable.

A further review of the history of energy exported to the grid by the 711 Newington PV power systems over the period since 2001 showed that 16 – 18% of the systems had not exported any energy and this could be indicative of a steady decline in the number of systems operating as designed.

2 Objectives and Method

The two main objectives of this analysis were

(1) to estimate the value of the energy produced by a working rooftop PV (photovoltaic) power system in a residential deployment in Sydney, and to compare this to the energy value of a typical household consumption profile

(2) to examine indicators of longer term performance of rooftop PV systems in a residential deployment

2.1 Energy value

Electricity prices are comprised of two main components. For typical customers the two components are roughly equal in size. The first is the retail component, which is comprised mainly of the cost of purchasing the electricity from the National Electricity Market (NEM) pool. All grid-supplied electricity in eastern Australia is traded through this pool, which settles every half hour. This results in a time varying price for electricity of up to $10,000 per MWh that represents the competitive cost of energy produced for that half hour to meet demand. In general, the price tends to be higher in higher demand periods but price spikes also commonly result from transmission constraints or generation plant outages at other times. Customers usually face less variable prices as retailers undertake financial hedging arrangements to enable them to present a simple price to their customer.

The second main component is a network component that reflects the cost of providing the transmission and distribution systems that deliver the electricity from the multiple points of generation to the customer. In general these costs are represented by tariffs that are the same for all customers of a particular class in a network region. Networks are natural monopolies and their costs are mainly related to the assets required to deliver energy. If accurately allocated, these costs would vary over time, by location and according to electrical demand at various points of the system at any particular moment. Because it is impractical to have such highly variable prices tailored to each individual customer, network tariffs are usually "postage stamp" prices that ascribe a fixed cost per kWh delivered. Where more sophisticated metering is available, network prices may incorporate peak demand charges (usually only for large customers) and time of day based price variation (becoming common even at residential level).

The data used for the energy value analysis was the measured annual load profile of energy produced by a sample of rooftop PV systems in the Sydney suburb of Newington. These dwellings formed part of the Athlete's Village for the 2000 Sydney Olympics and there are over 800 dwellings with 1 kW rooftop PV systems in this one suburb. The analysis is based on half-hourly logged data collected between 9 July 2004 and 8 July 2005. The PV system production, net energy into the house and net energy out of the house were logged every half hour using revenue class metering. The sample included 30 dwellings but two of these systems were not functioning during the sample period and were excluded from the energy value analysis.

2.1.1 Market Value Analysis

Calculation of the average market value of energy produced by the PV systems was done by multiplying the half-hourly production value for each system by the NSW pool price for the same period, and calculating an average value in ¢/kWh. In order to make a valid comparison, the market value of the energy consumed by the same households (excluding the impact of the PV system) was also calculated using the same method.

The 2004/05 pool prices were used to ensure any correlation between weather impacts on both PV production and pool price were preserved. As a cross check, the values were also calculated using 2006/07 market prices as these have been regarded as showing a significant cost increase due partially to the effects of the drought.

2.1.2 Network Value Analysis

Network value is more difficult to calculate. An analysis previously carried out by the Centre for Energy and Environmental Markets at UNSW in February 2006 showed that the PV production profile did not significantly reduce the peak demand of the residential load profile (Watt et al., 2006), so the value of PV energy from a local network point of view is probably quite low. However, it is more difficult to asses the value at different levels of the system as no pricing regime similar to the wholesale market exists for network costs.

We have assumed that residential time-of-use network tariffs represent a more cost reflective proxy for network costs than single price network tariffs. The value of the PV energy profile using time-of-use network tariffs was calculated and compared to the time-of-use household consumption profile to provide some indication of how valuable PV energy might be on average from a network perspective. The network value calculations were done using the latest 2007/08 network tariffs.

2.2 Reliability Analysis

In order to develop an overall picture of the reliability of a residential deployment of rooftop PV systems, billing data was collected for all installations with Newington's postcode that included a buy back tariff. The billing data included 711 individual PV installations and spans August 2001 to February 2007. The average period for which installations have billing data is approximately 3 years and 10 months.

The half-hourly interval data collected from the 30 sample sites was used to help determine markers in billing data that indicate an installation is working correctly. Two sites from the sample were found to operate unexpectedly, one site produced no electricity for the entire year and one produced approximately 10% of the electricity it was expected to produce. This resulted in these installations having consecutive quarterly billing periods where no electricity was exported to the grid.

Of the 28 installations operating as expected, the installation that exported the least amount of electricity exported an average of 20kWh per billing period and exported electricity during every billing period. All installations exported electricity to the grid when operating as expected.

These observations suggest that a PV installation that is working as expected will export some electricity to the grid at some stage in each billing period. If an installation fails to export electricity to the grid for two consecutive quarterly billing periods, it is reasonable to assume the installation is not operating as expected and so this was the marker used to identify non-performing sites.

3 Results

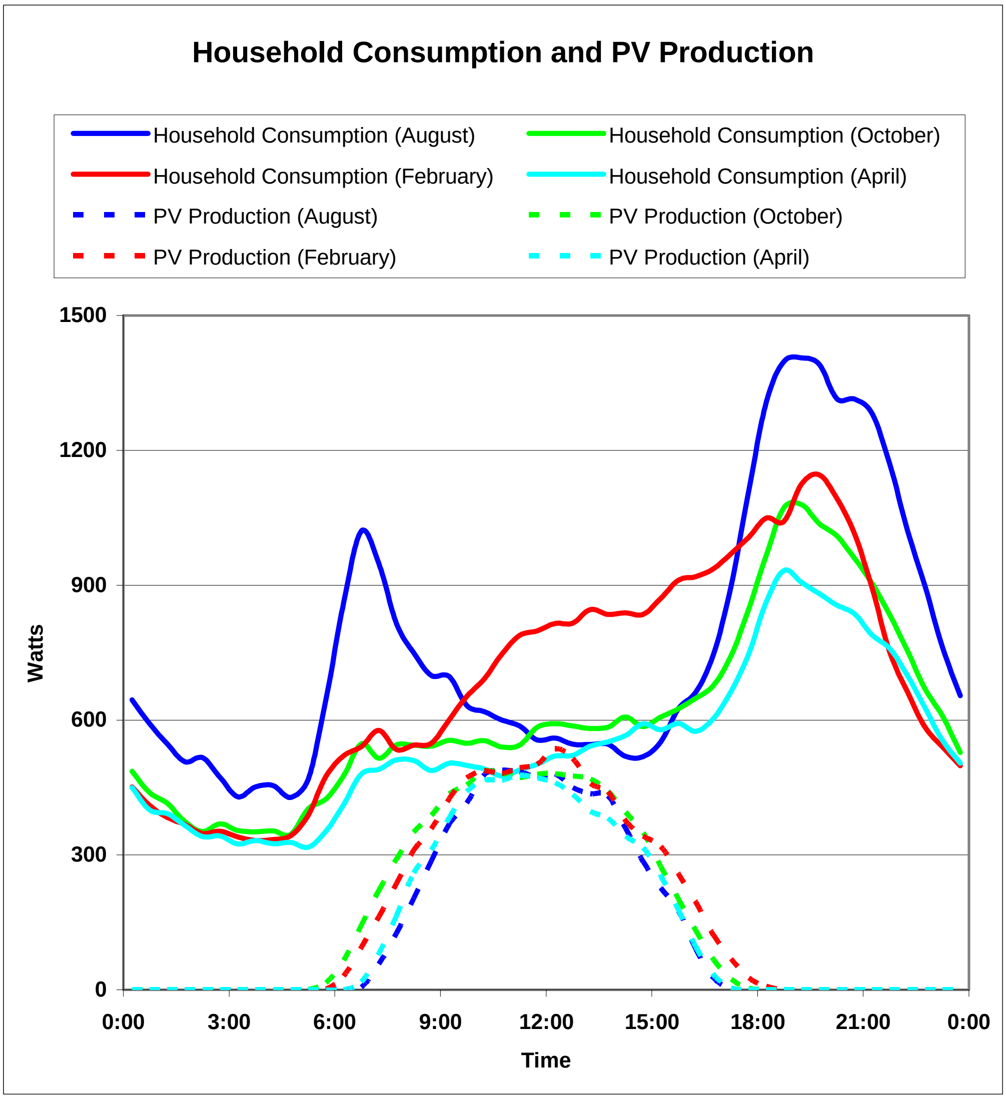
3.1 Energy Production and Consumption

The energy produced by the 28 working PV systems with interval data between 9 July 2004 and 8 July 2005 ranged between 999 and 1,349 kWh each, with an average of 1,223 kWh or 3.35 kWh per day.

Over the same period, these 28 households consumed an average of 5,732 kWh or 15.7 kWh/ day, with a range between 2,126 and 13,167 kWh for the sample period.

The contribution of the PV production to household consumption ranged from 10% to 51%, with an average of 25% for each system.

Daily average PV production and household consumption profiles (per house) are shown for each half-hourly time interval (Eastern Standard Time) for the months of August, October, February and April on the chart below:



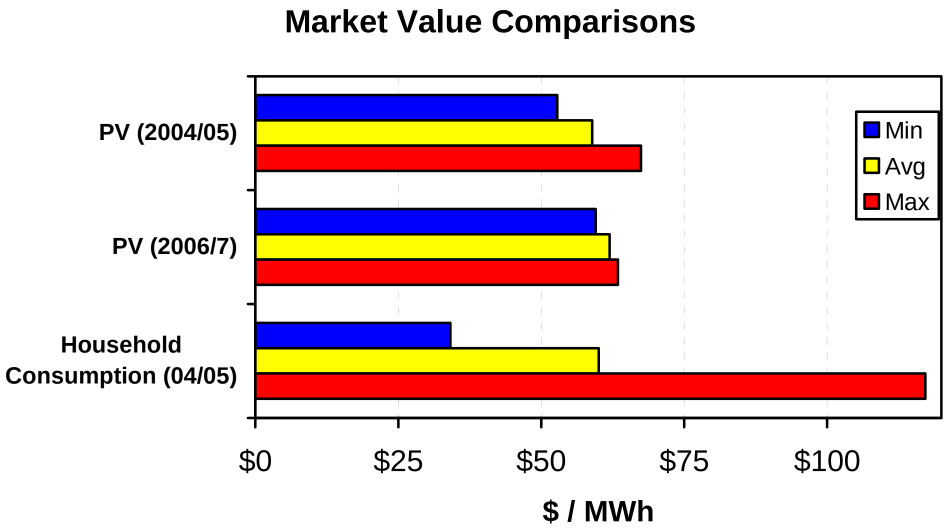
3.2 Market Value of PV Production and Household Consumption

Over the study period from 9 July 2004 to 8 July 2005, the NSW volume-weighted average of energy traded through the National Electricity Market was $45.31 per MWh. By contrast, in 2006/07 it was much higher at $73.67 per MWh.

The average cost of energy using the household consumption profiles and the 2004/05 pool price data was $60.10 per MWh.

Based on the actual production quantities, the average value of the PV production from all sites was $58.89 per MWh in 2004/05. Using the 2006/07 pool prices, the value rises only slightly to $61.96 per MWh, despite the overall market average being 63% higher.

The variation between PV systems using 2004/05 pool prices is relatively small – ranging from $52.81 to $67.46, which reflects the relatively consistent PV profiles. Interestingly, when the PV production average is calculated using the 2006/07 pool prices, the range is much lower – from $59.54 to $63.44. In contrast, the variation of household consumption average prices across different dwellings using the 2004/05 pool price data was quite large and ranged from $34.14 to $117.20 per MWh.



This analysis indicates that the energy market value of the average rooftop PV production in Sydney is slightly lower than the average cost of energy for a residential profile. There is no suggestion of a substantial correlation between high pool price periods and the production from PV systems, and this is robust across the quite different price data from 2004/05 and 2006/07.

The PV energy exported to the grid was also analysed to determine the market value of this buyback electricity. The average calculated was $53.93 per MWh with the 2004/05 market data and ranged between $6.30 per MWh to $107.91 per MWh. The average figure is lower than the PV production market value and shows that the most valuable PV energy is being used to offset the household consumption profile.

It should be noted that this analysis does not consider the value of the "renewableness" of the PV energy and its consequent greenhouse offset value. However since this is typically captured through the creation of renewable energy certificates at the time of installation, it would be unreasonable to count it again as an increase in energy value.

3.3 Network Value of PV Production and Household Consumption

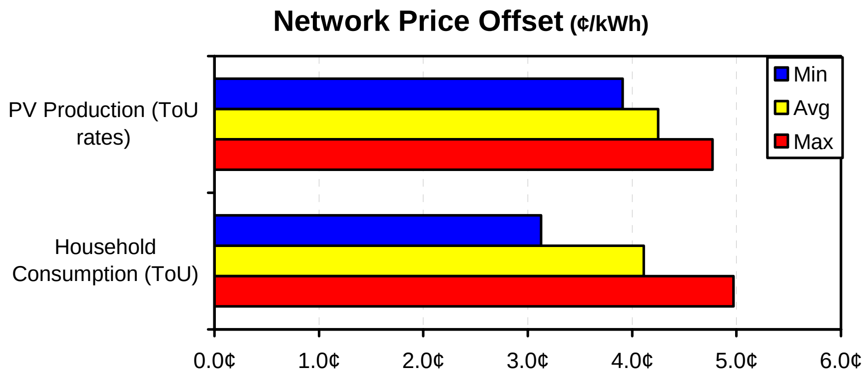
A technical review undertaken by the Centre for Energy and Environmental Markets at UNSW in February 2006 found that the PV systems contributed very little to reducing the peak household demand. While they had some potential benefit in peak reduction at the zone substation level, there was no contribution to peak reduction in the highest demand period at the state-wide level (Watt et al., 2006).

Given that network costs are mainly driven by providing capacity to meet peak demands, this would suggest that the value of PV in terms of offsetting network costs should be low.

As regulated monopolies, network prices are published and consistently applied to all customers in any particular class. However, as advances in metering have provided enhanced measurement capability, networks have moved to introduce more cost reflective pricing regimes. EnergyAustralia has both an inclining block "anytime" price structure and a time of use pricing structure for residential customers. The time of use structure charges different amounts depending on what time of day the energy is used. This is held to be more reflective of network costs and was used for this analysis. The time of use (TOU) network rates for 2007/08 were 0.6110¢/kWh off peak, 2.4361¢/kWh shoulder and 12.8111 ¢/kWh during peak times (exclusive of GST). The peak period is between 2:00pm and 8:00pm on working weekdays. The shoulder period is from 7:00am to 2:00pm and from 8:00pm to 10:00pm working weekdays and from 7:00am to 10:00pm weekends and public holidays. The off peak period is all other times.

Based on the actual production quantities using the TOU prices, the average energy value of the household consumption was calculated to be 4.11 ¢/kWh with a large variability, ranging from a low of 3.13 ¢/kWh to 4.97 ¢/kWh.

Using the same network TOU tariffs, the average network price offset by the PV production from all sites was 4.25 ¢/kWh, ranging from a low of 3.91 ¢/kWh to a high of 4.77 ¢/kWh.



When calculated using this more reflective tariff, the value of the average PV production profile is slightly higher than the household consumption profile.

The network TOU tariffs (2007/08) were also used to analyse the network value of energy exported to the grid by the households. The average PV energy value exported to the grid was found to be 3.89 ¢/kWh, and ranged between 0.59 ¢/kWh to 7.18 ¢/kWh.

3.4 Buyback quantity

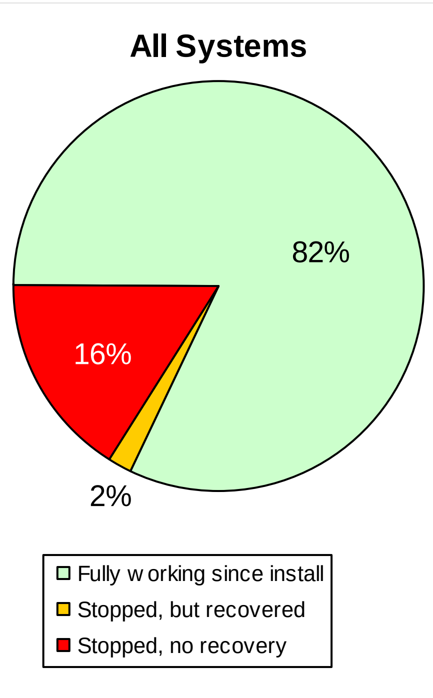
The interval data from the 30 Newington dwellings was analysed to determine the amount of energy exported to the grid during the 04/05 sample period. The average amount of buyback energy was calculated to be 365 kWh for the 28 working systems which was 30% of the average 1,223 kWh total PV production. The amount of energy exported to the grid ranged from 80.23 kWh to 762.1 kWh, with the highest buyback amount corresponding to the dwelling with lowest household energy consumption (2,588 kWh), and the lowest buyback amount corresponding to the dwelling with the highest household consumption (13,167kWh).

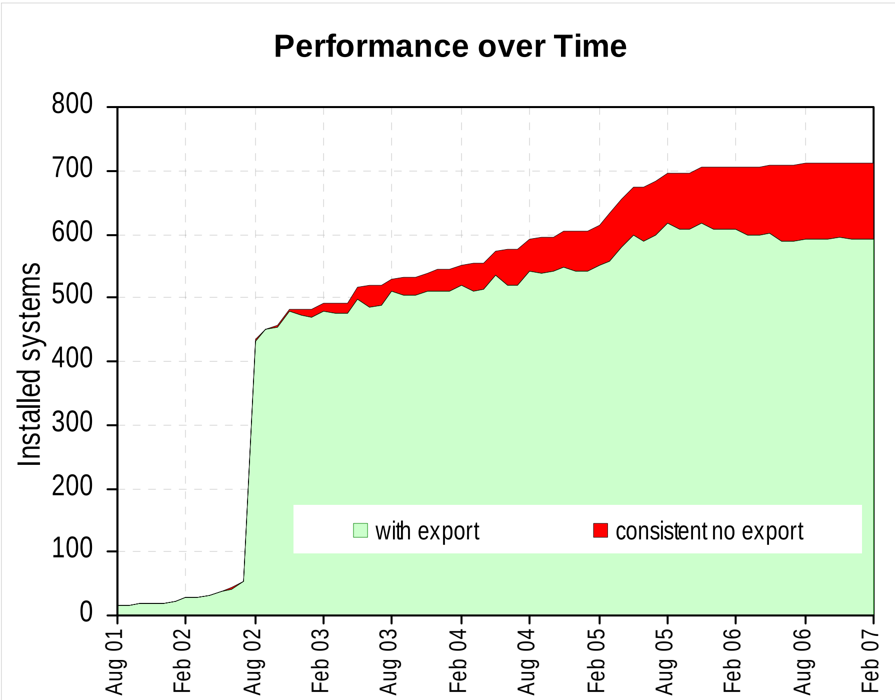
3.5 Long term performance

Because two of the 30 systems studied exhibited poor performance - no production in one case and about 10% output in another, a wider review of long term performance of Newington PV system was undertaken.

Based on the method outlined in section 2.2, the buyback component of billing data for 711 PV equipped Newington homes installed during the period August 2001 to February 2007 was analysed. It identified installations where a positive buyback quantity had been recorded at some time and subsequently more that two consecutive quarterly billing periods showed no exported energy.

There were 129 installations (18%) that had, at some period, shown this evidence of non-performance. Of these, 115 (16% of the total) exhibited lack of export continuously up to the latest period in the sample. The results are shown graphically below.





While these indicators are not definitive, and there may be other explanations for individual cases, there is sufficient evidence to suggest that rooftop PV systems may require more vigilant monitoring and maintenance to ensure continued satisfactory performance. Further examination of this area may be warranted.

4 Conclusions

This analysis demonstrates that rooftop PV systems of the type installed at Newington, located in Sydney produce energy that has a market energy value similar to or slightly (2%) lower than the wholesale cost of the household consumption. There is no evidence that the typical profile of production from such rooftop PV systems in Sydney correlates more with higher pool prices than the underlying household consumption pattern.

Further analysis of the rooftop PV production profiles shows that the network value using Time of Use network tariffs is very close to the network value for the underlying household consumption figure. This supports earlier findings that PV production profiles provide little benefit to networks, at least for Sydney based systems.

Typical 1kW rooftop PV systems in Sydney could be expected to deliver an average of about 1200-1250kWh per year, with approximately 30% of this (365kWh) being expired to the grid.

The energy exported by PV systems to the grid has a lower value than the average value, suggesting that the energy consumed within the household has the highest value.

Of the 711 systems with available data, 129 (18%) exhibited behaviour that suggested they were not performing as expected, and the decline in reliability was relatively constant over time at about 3.5% of systems per year. This could suggest that more attention may need to be paid to vigilant monitoring and maintenance to ensure continued satisfactory performance.

5 References

Watt, M., Passey, R. Barker, F. and Rivier, J., 2006, Newington Village – An Analysis of Photovoltaic Output, Residential Load and PV's ability to Reduce Peak Demand, Report for the NSW Department of Planning, CEEM UNSW

Report prepared by Robert Simpson & Neil Gordon for the Demand Management group, April 2008